A PRELIMINARY STUDY OF THE BIOLOGY OF *ENTOMOBRYOIDES PURPURASCENS* (PACKARD, 1873) (COLLEMBOLA:ENTOMOBRYIDAE) [1, 2]

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INTRODUCTION

Entomobryoides purpurascens was described very briefly by Packard (1873) and was redescribed most recently by Christiansen (1958). It is a comparatively large species, widely distributed, and common in woodpiles and similar situations in southwestern Quebec. It was selected for study because of its ready availability and the lack of any previous detailed information on its biology. The original intention, to work out the life cycle and feeding habits, led to the discovery of a previously unsuspected 'diapause' or period of arrested development.

The species has been mentioned many times in the literature, as evidenced by a long list of references in Salmon's (1964) bibliography, but has received detailed consideration only by Christiansen *(op. cit.)* and Willson (1960). The former elucidated some aspects of its taxonomy, while the latter examined certain light and temperature relationships. Other literature on the species relevant to the present study has been covered in four recent papers: Christiansen (1964), Joose and Veltkamp (1970), Kevan and Kevan (1970) and Butcher *et al.* (1971).

MATERIAL AND REARING METHODS

All of the animals used were collected by means of a simple aspirator in a single woodpile in the Morgan Arboretum, Ste-Anne-de-Bellevue, west Montreal Island, Province of Quebec. The cut wood in the pile originated from a mixture of tree species, mostly American beech *(Fagus grandiflora* Ehrh.) and various birches *(Betula* spp.).

[1] Based on data presented in an unpublished thesis by the first author: (Stainer, 1969).

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The rearing chamber used in the laboratory (Fig. 1) was designed to combine maintenance of a high humidity with maximum ease of observation. It was based on a design originally conceived by Mr. Lynton Martin of Sault Ste. Marie, Ontario, and subsequently much modified by various research workers in the soil zoology laboratory of the Department of Entomology, Macdonald Campus, McGill University. Inside the larger chamber, the animals were confined in a variety of containers, but for all of the work reported here, '2-dram' glass vials[4] with polyethylene 'snap' caps were used. A hole was blown in the base of each vial so that a 5mm. layer of plaster of Paris subsequently placed there would be in contact with the moist plaster base of the large rearing chamber. For rearing the larger stages of the animals, the centres of the snap caps were cut out and replaced with fine nylon mesh. Because they could pass through the mesh with ease, the smallest stages were reared in vials with solid caps. The entire apparatus was placed in a temperature-controlled incubator. Illumination was provided by a 10-watt incandescent bulb (Sylvania) controlled by a time switch (Paragon APT5-0). Intensity of illumination at the level of the rearing chambers varied between 15 and 25 foot-candles. The photophase was of 15¾ or 16 hours' duration.

Animals were transferred between containers using a fine, moistened camel-hair brush and, when necessary, carbon dioxide as an anaesthetic. An abundant supply of baker's yeast, augmented by volunteer moulds, served as food. Vials were sterilized with 95 per cent ethanol before use and then dried. This kept the mould growth down to a manageable level for the duration of the experiments.

Groups of *E. purpurascens* were cultured in the laboratory under various regimes of temperature to ascertain rearing requirements, development times and readiness to ovipost.

Samples of the species were also collected from the field at regular intervals in the spring and sporadically at other seasons. Observations on behaviour in the field and spot checks of temperature were made whenever the samples were collected. The specimens were killed and mounted in Hoyer's medium (Krantz, 1970) on microscope slides and examined in order to detect changes in the maturity, sex ratio and diet.

[4]Approximately 11 ml.

LIFE CYCLE

In early April, the animals are active and feeding (Table I). No mature male has been found at this time in the populations studied (Table II), but it is possible that some females are mature at this time. Little change takes place until the end of April or early May. Then, at a date probably dependent upon the severity of the preceding winter, the first mature males appear. Within a week the proportion of males reaches its summer level of 17 to 30 per cent of the *total* population. By the following week the females have apparently been fertilized and are ready to lay eggs. At this time of year they will oviposit immediately upon being brought into the laboratory. In the field, oviposition begins by the middle of May. Incubation periods of 16 days at 18°C., 7 days at 22°C. and 6 days at 25°C. suggest that, at the daily maximum temperatures of a woodpile (8° to 15°C.), the incubation period would be much longer, perhaps over 40 days.

Laboratory studies indicate the occurrence of a minimum of seven nymphal instars before maturity is reached. At the July and August daily mean temperatures in the woodpiles (15° to 20°C.), the duration of each stadium is about 7 to 9 days. In a favorable year, some of the spring brood may be mature by mid-August and it is possible that there might be a second brood at this time. In most years, however, it is unlikely that this takes place, for the animals appear always to enter a state of arrested development about the first of September. Oviposition ceases and mature males disappear from the population. Only a small proportion of the remaining animals continue to feed. Collections of females brought from the field into the laboratory at this time of year and kept (even with a long-day photophase) at 25°C.—normally a suitable rearing temperature at other times—died months later without having oviposited.

The animals pass the winter amongst the wood and, by late January, the physiological requirements for the termination of the period of arrested development have been at least partially met. The delay between collection and oviposition in the laboratory—about 40 days in late January—steadily decreases at a rate of change which seems to be dependent upon the severity of the winter.

DIET

The feeding habits of *E. purpurascens* were examined in some detail (Table I). Fungal matter, both hyphae and spores, makes up the bulk of the normal diet. The only other important constituent is pollen. This is apparently wind-borne, coming from two sources, the surrounding trees in the spring and a different source, probably goldenrods *(Solidago* spp.) in the summer. Collembolan remains also appeared regularly in the gut contents of both field and laboratory specimens. Most of these were probably of *E. purpurascens,* but, in one case, they were definitely of a different species, *Lepidocyrtus* sp. This probably indicates mere scavenging; no evidence of predation (cannibalism) has been found in the laboratory. Of interest is the fact that no higher plant material, other than pollen, was found in the guts. Further, the possibility is remote that any significant amount of unidentified material was of this origin. This suggests strongly that *E. purpurascens* does not directly attack wood or leaves, although it could indirectly cause damage by disseminating spores.

DISCUSSION

The determination of the number of instars in Collembola before maturity presents problems. In the past, workers have attempted this using measurements of large samples and subsequent elaborate statistical analysis (Agrell, 1948; Janetschek, 1967). Their conclusions would have been more convincing, however, had they been supported by rearing data. The series measured in the present research showed that the measurement of a structure in a given animal of known instar was dependent upon the temperature at which the individual had been reared. This would explain the absence of recognizable size classes in a non-uniform natural environment.

Rearing studies confirmed the existence of a period of arrested development or 'diapause' and indicated that it may be broken by exposure for one to two months at 5° C. The cause of the arrest is not yet clear. It is known, however, that it is not obligate because, at 25°C. in the laboratory, the animals will complete a life cycle in 30 to 35 days without any observable arrest, but once entered, arrestation cannot be overcome merely by raising the temperature.

The winter populations present an interesting problem, for there appear to be two classes of animals entering 'diapause' in the fall. One is the normal new generation; the other seems to comprise animals which have already lived through one reproductive season, for they are much too large to belong to the new brood. It seems that these large animals may be females that go through a second reproductive season, losing their external sexual characters in the interval. This is not as improbable as it might seem, for a similar situation has been shown by Verhoeff (1933, 1939) to occur in some millipedes (the hexapod larval stages of which, incidentally, exhibit certain features somewhat reminiscent of Collembola). This hypothesis cannot be tested, however, until a reliable method is found for sexing living adults.

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ABSTRACT.—The life cycle and diet of *Entomobryoides purpurascens* are outlined, and an account of a previously undescribed rearing apparatus is given. Laboratory studies indicate a minimum of seven nymphal instars. There is usually only a single generation per year although development can be more rapid at higher temperatures in the laboratory. Field populations in the autumn seem to consist only of females, which enter a state of arrested development which is not terminated until after exposure to low temperatures. The food comprises mainly fungal hyphae, but appreciable quantities of pollen are eaten. Some scavenging on the bodies of Collembola, including *E. purpurascens,* occurs. Overwintering field populations include some individuals of extra large size, but which exhibit immature external characters. It is suggested that these may be adult females which have reverted to a 'nymphal' state (as occurs in some millipedes) before assuming a second breeding period in the following season. John E.R. Stainer and D. Keith McE. Kevan, Department of Entomology, McGill University, Macdonald Campus, Ste-Anne-de-Bellevue, Province of Quebec, H9X 3M1, Canada.

Descriptors: Collembola, Entomobryidae; *Entomobryoides;* Biology; Quebec.

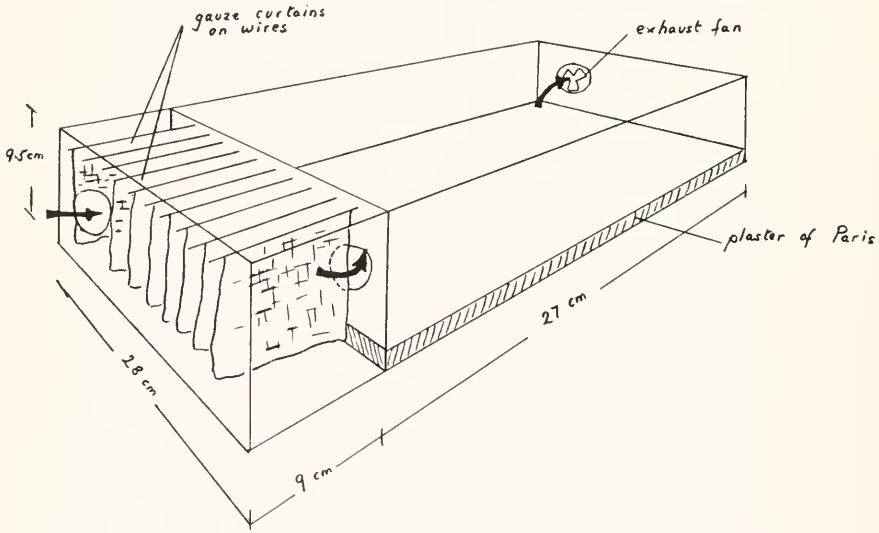

Fig. 1 Rearing apparatus for organisms requiring high humidity. Air enters at the left, is moistened by the wet curtains, passes into the rearing chamber at the right and leaves through the exhaust port. The exhaust fan is driven by a small electric clock motor. A transparent lid covers the whole apparatus.

TABLE I

Gut contents of samples of *Entomobryoides purpurascens* collected in the Morgan Arboretum, Ste-Anne-de-Bellevue, Quebec, in 1968-69.

Collection date	No. in sample	No. of specimens containing:				
		Indet. debris	Pollen	Spores	Hyphae	Collembolan remains
15.IV.68	50	42	2	1	-	1
22.IV.68	50	34	7	1	5	1
29.IV.68	50	26	1	18	7	2
6.V.68	57	43	-	-	-	5
13.V.68	54	44	-	5	3	1
27.V.68	68	47	2	6	1	2
11.VI.68	44	17	4	24	11	2
25.VI.68	55	18	2	32	27	3
8.VII.68	55	19	2	31	17	3
8.IX.68	57	50	-	6	1	3
23.IX.68	55	43	-	5	1	1
30.IX.68	39	31	-	8	-	-
14.X.68	36	32	-	4	-	-
5.XI.68	56	51	-	3	-	1
13.IV.69	52	14	-	39	2	1
21.IV.69	52	29	-	24	4	3
30.IV.69	50	28	-	25	5	2
5.V.69	54	30	2	14	6	1
12.V.69	53	24	1	20	7	-
17.V.69	54	21		23	8	-

TABLE II

Percentage mature males in samples of *Entomobryoides purpurascens* collected in the Morgan Arboretum, Ste-Anne-de-Bellevue, Quebec in 1968.

Collection date	Total no. in sample	Mature Males	
		No.	%
19.I.68	66	0	0
25.III.68	50	0	0
15.IV.68	50	0	0
22.IV.68	50	0	0
29.IV.68	49	1	2
6.V.68	57	12	19
13.V.68	54	12	22
27.V.68	68	12	17.5
11.VI.68	44	9	20
25.VI.68	55	16	29
8.VII.68	55	14	25
8.IX.68	57	4	7
23.IX.68	55	0	0
30.IX.68	39	0	0
14.X.68	54	0	0
5.XI.68	56	0	0